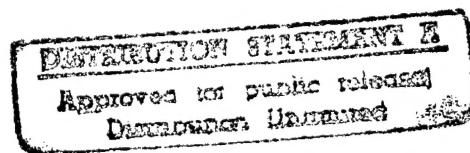


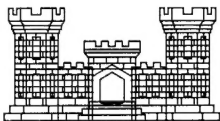
Limited Energy Study (Glass)

Energy Engineering Analysis Program (EEAP) Fort Knox, Kentucky

Final Report Executive Summary



CONTRACT #DACA01-94-D-0034
SYSTEMS CORP PROJECT #94013.02
OCTOBER 28, 1994



Louisville District-
US Army Corps
of Engineers

SYSTEMS*corp*

SYSTEMS ENGINEERING AND MANAGEMENT CORPORATION

Cherokee Place, Suite 306 ♦ 2200 Sutherland Avenue ♦ Knoxville, Tennessee 37919

Telephone 615-521-6536 Fax 615-524-7514



DEPARTMENT OF THE ARMY
CONSTRUCTION ENGINEERING RESEARCH LABORATORIES, CORPS OF ENGINEERS
P.O. BOX 9005
CHAMPAIGN, ILLINOIS 61826-9005

REPLY TO

ATTENTION OF: TR-I Library

17 Sep 1997

Based on SOW, these Energy Studies are unclassified/unlimited.
Distribution A. Approved for public release.



Marie Wakefield,
Librarian Engineering

TABLE OF CONTENTS

FY94 LIMITED ENERGY STUDY (GLASS), FT. KNOX, KY

1.	EXECUTIVE SUMMARY	1-1
1.1	Synopsis	1-1
1.2	Introduction	1-1
1.2.1	Scope of Work	1-1
1.2.2	Organization of the Final Report	1-2
1.3	Present and Historical Electrical Energy Consumption	1-2
1.4	Energy Conservation Opportunities Investigated	1-2
1.4.1	ECOs Recommended	1-4
1.4.2	ECOs Rejected	1-4
1.4.3	FEMP and ECIP Projects Developed	1-4

19971023 169

1.1 SYNOPSIS

Systems Corp surveyed and completed energy analyses for 72 representative buildings at Fort Knox, categorized as gymnasium, print shop, maintenance, and warehouse facilities. The energy conservation opportunities (ECOs) evaluated were infra-red heat and window/wall insulation. Cost estimates were prepared using MeansData for Windows Spreadsheets, Version 2.0a. Life cycle cost analyses were performed using the Life Cycle Cost in Design (LCCID) computer program. Project descriptions and DD1391 forms were prepared for two Energy Conservation Investment Program (ECIP) projects. The total of the two projects that were developed represent \$538K in annual savings and a total discounted savings of \$10.1M in the twenty year life of the projects. The simple paybacks average 6.3 years and the savings to investment (SIR) for the two ECIP projects is 2.75. In addition, five FEMP projects were developed for projects totaling less than \$1,000,000 investment costs. FEMP projects one through four are infra-red heat averaging a payback of 6.1 years and an SIR of 2.8. The fifth FEMP project is window insulation for two buildings. This project is for \$17,600 of investment with a 4.74 year payback and an SIR of 4.42.

1.2 INTRODUCTION

Systems Engineering and Management Corporation (Systems/Corp) was contracted by the Mobile District of the United States Army Corps of Engineers in July 1994 to perform a limited energy study for 72 buildings at Fort Knox, Kentucky. The project includes a study of infra-red heat and window/wall insulation.

1.2.1 Scope of Work

1. Evaluate selected energy conservation opportunities (ECOs) to determine their energy savings potential and economic feasibility.
2. Conduct a limited site survey of selected buildings or areas to insure any methods of energy conservation which are practical and have not been evaluated in any previous energy study have been considered and the results documented.
3. Determine efficiency of existing systems. Determine the replacement option with the highest SIR.
4. Provide complete programming or implementation documentation for all recommended ECOs.
5. Prepare a comprehensive report to document the work performed, the results, and the recommendations.

1.2.2 Organization of the Final Report

The submitted material for this report consists of the following:

- Volume I: Executive Summary, Methods and Approach - ECIP Project 1: Infra-red Heat at 36 buildings
ECIP Project 2: Infra-red Heat at 31 buildings
- Volume II: Scope of Work, Interim Review Comments and Responses, Interim Review Presentation and Building 2647 material
FEMP Project 4: Infra-red Heat at 22 buildings
FEMP Project 5: Window/wall Insulation at two buildings

1.3 PRESENT AND HISTORICAL ELECTRICAL ENERGY CONSUMPTION

The baseline energy consumptions and the energy conservation opportunity energy consumption were determined using spreadsheets and manual calculating to model system energy consumption. These have been included in *Section 2* of this report.

The natural gas and fuel oil consumption, and total costs for FY93 are shown in *Figure 1.3.1 Fort Knox Natural Gas and Fuel Oil*. The natural gas and fuel oil costs used to calculate the savings for the project are as follows:

Natural Gas	= \$4.62/MBtu
Fuel Oil	= \$6.60/MBtu

1.4 ENERGY CONSERVATION OPPORTUNITIES INVESTIGATED

Systems Corp analyzed two energy conservation opportunities (ECOs) at Fort Knox, Kentucky. The analysis was performed utilizing energy models developed by Systems Corp and data collected during the field survey of the facilities at Fort Knox. Each ECO was evaluated to determine the potential energy savings, dollar savings, implementation costs, simple payback, life cycle cost, and savings to investment ratio (SIR). The two ECOs that were evaluated are as follows:

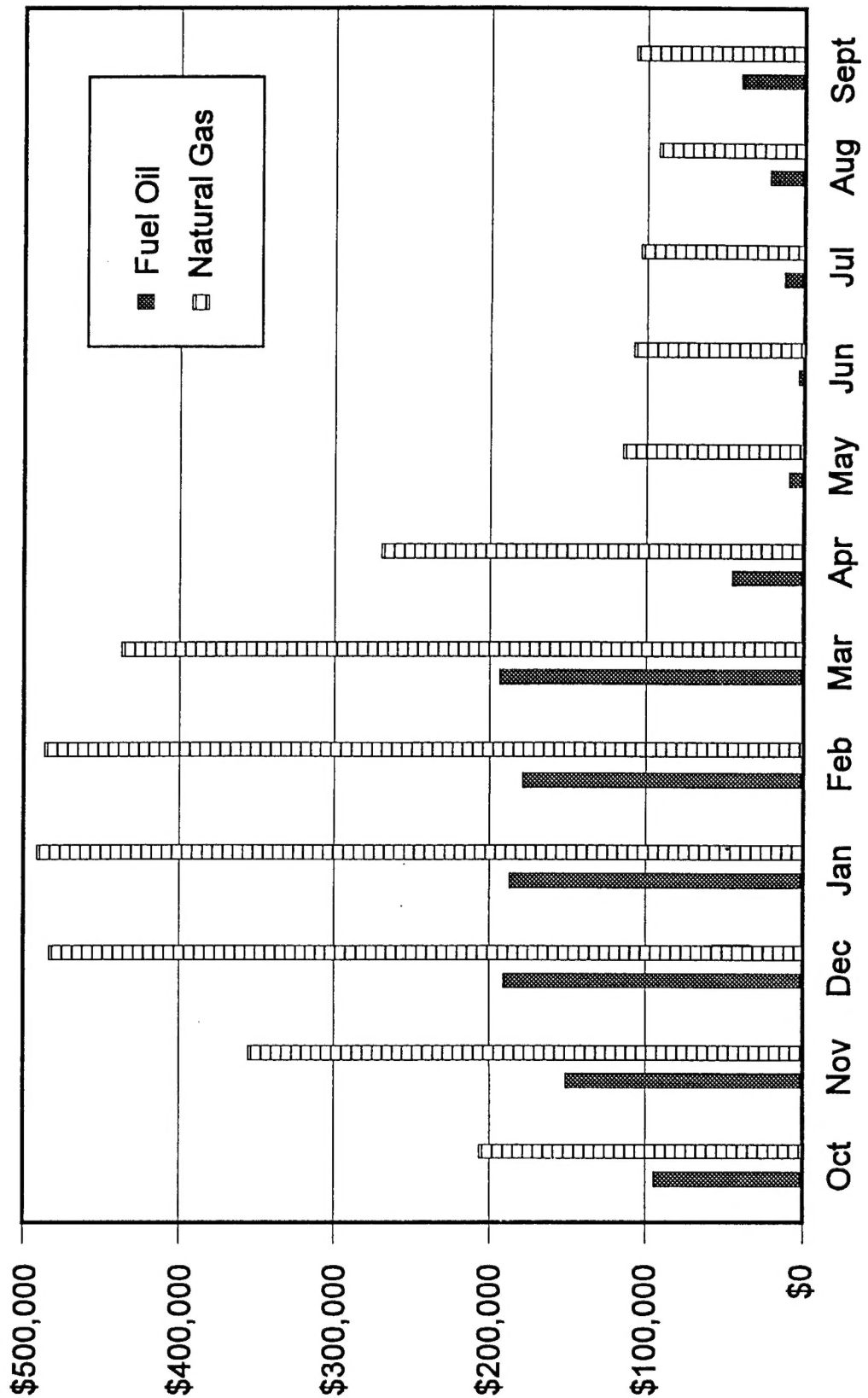
ECO - 1 Infra-red Heat

ECO - 2 Window/Wall Insulation

FORT KNOX FY 93

Fuel Oil and Natural Gas Consumption

Figure 1.3.1



1 EXECUTIVE SUMMARY

FY94 LIMITED ENERGY STUDY (GLASS), FT. KNOX, KY

Systems Corp's energy analysis models were used to determine the savings achieved for implementing each ECO in the facilities evaluated. MeansData for Windows Spreadsheets, Version 2.0a cost estimating software was used to estimate the implementation cost of each ECO in each facility evaluated. The U.S. Army Corps of Engineers' Life Cycle Cost in Design, Version 1.0, Level 80, software was used to perform life cycle cost analyses and determine the SIR of each ECO for each facility evaluated.

1.4.1 ECOs Recommended

Systems Corp recommended both ECOs evaluated be implemented, but not in every area surveyed. The following is a list of the ECOs recommended to be implemented by area surveyed. The criteria for recommendation is a favorable simple payback and savings to investment ratio (SIR).

ECO - 1: Warehouse buildings
Maintenance buildings
Hangars

ECO - 2: Gymnasiums

1.4.2 ECOs Rejected

ECO-2, Wall Insulation at the Print Shop (Bldg 2647) was rejected due to the large investment required. Due to the age of the facility, it was the decision of Ft. Knox DPW to remove the building from the project. Refer to Appendix D for The Life Cycle Cost Analysis, Cost Estimate and Calculations for this building.

1.4.3 ECIP and FEMP Projects Developed

Systems Corp developed two ECIP projects and five FEMP projects. The two ECIP projects include infra-red heat at 67 buildings. Some of the FEMP projects include the same buildings in the ECIP projects. This will allow Fort Knox the flexibility to pursue either type of funding. FEMP projects 1 & 2 include the same buildings as ECIP Project 1 except the FEMP projects were broken into two smaller projects with each project requiring less than \$1,000,000 investment. FEMP Projects 3 and 4 are similar to ECIP Project 2, except FEMP Project 4 includes buildings 5220 and 5253. FEMP Project 5 includes the two buildings evaluated for window insulation. The following table, Table 1.4.3, summarizes the savings and investments for each project.

TABLE 1.4.3
FORT KNOX ENERGY STUDY:
PROJECT SUMMARY

ECO NUMBER	BUILDING NUMBER	TOTAL INVESTMENT	1ST YEAR SAVINGS	SIMPLE PAYBACK	SIR	AIRR
1	86	\$49,565	\$9,887	5.01	4.13	10.67%
1	92, 94, 98, 100 & 101	\$292,227	\$62,199	3.66	4.30	10.89%
1	482	\$74,902	\$12,479	6.00	2.65	8.25%
1	483	\$74,902	\$12,550	5.97	2.66	8.28%
1	484	\$74,902	\$7,027	10.66	1.85	6.33%
1	485	\$74,902	\$12,461	6.01	2.65	8.24%
1	486A, 486B & 486HB	\$158,261	\$25,713	6.16	2.59	8.12%
1	FEMP PROJECT 1	\$803,262	\$159,912	5.02	3.24	9.34%
1	2754 & 2755	\$66,417	\$10,419	6.37	2.49	7.91%
1	2756 & 2757	\$66,417	\$10,414	6.38	2.49	7.19%
1	2786 - 2789	\$121,125	\$10,387	11.66	1.65	5.71%
1	2955, 2959 & 2960	\$111,176	\$10,643	10.45	1.87	6.37%
1	2961, 2963 & 2964	\$117,512	\$16,755	7.01	2.23	7.23%
1	2969 & 2972	\$78,484	\$11,910	6.59	2.40	7.72%
1	2970 & 2971	\$78,484	\$11,896	6.60	2.40	7.71%
1	2958, 2973, 2974, 2979 & 2980	\$241,454	\$22,401	10.78	1.82	6.22%
1	FEMP PROJECT 2	\$881,069	\$104,825	8.41	2.06	6.90%
1	ECIP PROJECT 1 INCL. FEMP 1 & 2	\$1,684,331	\$264,736	6.36	2.62	8.20%
1	2762 - 2767, 2778 & 2781	\$483,650	\$48,583	9.96	2.03	6.82%
1	2770	\$271,299	\$73,478	3.69	5.57	12.34%
1	2942 - 2944	\$226,146	\$44,565	5.07	3.12	9.14%
1	FEMP PROJECT 3	\$981,094	\$166,626	5389.00	3.26	9.38%
1	5220	\$78,231	\$25,402	3.12	5.05	11.79%
1	5253	\$45,837	\$15,647	2.93	5.38	12.15%
1	6113-6118, 6142-6147	\$503,778	\$77,721	6.48	2.44	7.80%
1	6560-6564, 6576, 6577	\$263,339	\$36,858	7.14	2.22	7.29%
1	6592	\$37,462	\$4,810	7.79	2.41	7.73%
1	FEMP PROJECT 4	\$928,646	\$160,076	5.80	2.74	8.43%
1	ECIP PROJECT 2 INCL FEMP 3 & 4 EXCEPT 5220 & 5253	\$1,785,673	\$286,015	6.24	2.86	8.66%

Annual
Energy
Savings
14,275

12,365

12,807

31,172

16,126

40,012

TABLE 1.4.3
FORT KNOX ENERGY STUDY:
PROJECT SUMMARY

ECO NUMBER	BUILDING NUMBER	TOTAL INVESTMENT	1ST YEAR SAVINGS	SIMPLE PAYBACK	SIR	AIRR
2	5297	\$8,973	\$1,855	4.74	4.42	11.05%
2	6591	\$8,973	\$1,855	4.74	4.42	11.05%
2	FEMP PROJECT 5	\$17,946	\$3,710	4.74	4.42	11.05%

806

Proj #	1st yr \$ savings	Annual Energy Savings MBTU
ECIP 1	267,732	31,178
FEMP 3	166,686	22,413
FEMP 4	160,074	16,360
FEMP 5	3,710	802
TOTAL	512,148	76,689

TABLE 3.1
PROJECT SUMMARY:
INFRA-RED HEAT - ECIP PROJECT 1
(INCLUDING FEMP 1 & 2)

ECO. NUMBER	BUILDING NUMBER	BASELINE ENERGY (MMBTU)	ECO ENERGY (MMBTU)	ENERGY SAVINGS (MMBTU)	1ST YEAR SAVINGS	INVESTMENT COST	NON-ENERGY ANNUAL RECURRING	TOTAL NON-ENERGY NON-RECURRING	SPB (YR)	SIR
1	92	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	5.01	4.13
2	93	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	3.66	4.30
3	94	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.00	2.65
4	95	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	5.97	2.66
5	96	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	10.66	1.85
6	97	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.01	2.65
7	98	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.16	2.59
8	99	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	5.02	3.24
9	100	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	5.37	2.49
10	101	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	2.49
11	102	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.65
12	103	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
13	104	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	2.23
14	105	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	2.42
15	106	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	2.42
16	107	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
17	108	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
18	109	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
19	110	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
20	111	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
21	112	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
22	113	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
23	114	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
24	115	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
25	116	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
26	117	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
27	118	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
28	119	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
29	120	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
30	121	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
31	122	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
32	123	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
33	124	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
34	125	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
35	126	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
36	127	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
37	128	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
38	129	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
39	130	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
40	131	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
41	132	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
42	133	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
43	134	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
44	135	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
45	136	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
46	137	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
47	138	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
48	139	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
49	140	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
50	141	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
51	142	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
52	143	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
53	144	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
54	145	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
55	146	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
56	147	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
57	148	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
58	149	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
59	150	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
60	151	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
61	152	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
62	153	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
63	154	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
64	155	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
65	156	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
66	157	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
67	158	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
68	159	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
69	160	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
70	161	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
71	162	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
72	163	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
73	164	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
74	165	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
75	166	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
76	167	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
77	168	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
78	169	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
79	170	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
80	171	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
81	172	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
82	173	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
83	174	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
84	175	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
85	176	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
86	177	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
87	178	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
88	179	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
89	180	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
90	181	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
91	182	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
92	183	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
93	184	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
94	185	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
95	186	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
96	187	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
97	188	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
98	189	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
99	190	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87
100	191	100	100	0	\$0.00	\$0.00	\$0.00	\$0.00	6.35	1.87

TABLE 4.1
PROJECT SUMMARY:
INFRA-RED HEAT - ECIP PROJECT 2
(INCLUDING FIMP 3)

[illegible]

100-443887-100

100-443887-100

100-443887-100

100-443887-100

100-443887-100

100-443887-100

100-443887-100

100-443887-100

100-443887-100

100-443887-100